SIMULATION AND OPTIMIZATION OF A HYBRID SEMI-TRANSPARENT INDIRECT SOLAR DRYER BY USING SOFT COMPUTING TECHNIQUE

SHORT SYNOPSIS

Submitted in partial fulfillment of the requirement of the degree of

DOCTOR OF PHILOSOPHY

to

Manav Rachna University

by

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ABSTRACT

The improvement of cleaner and self-sustainable system are essential so that the non-renewable energy source reliance and an unnatural weather change can be diminished. Display correspondence is an endeavor to investigate the accessible writing on Photovoltaic Thermal (PVT) air collector and its integration with solar dryers. Solar drying is a standout amongst other technique to prevent agricultural goods from spoilage for a long time. Per capita power generation is low in developing countries; subsequently the power utilizes for drying purpose can't be economically and environmentally justified. In this synopsis, literature survey on various types of dryers has been done and with the research gap objectives of the work has been identified.

Keywords: Solar Dryer, Hybrid Dryer, Green House, Photovoltaic Thermal

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Chapter 1. Introduction

Agriculture has always been a core sector of Indian economy. About two-third of our work force is employed in agriculture and 70 per cent of population is dependent on agriculture. The importance of agriculture is evident from the fact that about 25 per cent of the country's GDP is contributed by this sector. Research advances in crop science including crop production techniques have given the nation confidence to produce food grain not only to meet the present requirement but to achieve the targets set for the coming decade. As more food is being produced and larger amount of crops are being handled per unit area, the problem of harvesting, threshing, storage and drying have become both gigantic and important. Inadequate attention to the post-harvest sector in the past has been resulting in high order of losses to farm produces from the stage of harvesting of crop till their use. In numerous creating nations, expansive measure of post-harvest loss happen from waste, contamination, attack by insects, birds, rodents and deterioration during storage. The moisture present in the sustenance item is the most vital factor in deciding the degree of deterioration during storage. At the season of collecting, the majority of horticultural yields have high moisture content. Harvest with high moisture break down for a few reasons, for example, development of microflora, especially aerobic species of mould. But vegetables and fruits being perishable commodities need to be preserved to maintain their quality for a long period without spoilage. The different methods that can be adopted for enhancing the shell life and increase the value of fruits and vegetables are drying or dehydration, freezing, canning and juice extraction.

Drying is a very common method for small, medium and industrial scale preservation of fruits and vegetables. Because of concentrated frame, minimal effort, accommodation and simple transportability, the dried foods grown from the ground items have been exceptionally prevalent among the consumers. Utilization of appropriate drying methods can altogether diminish the post-harvest losses of products of the soil. The utilization of sunlight based vitality for this reason has wide degree. The customary strategy, still broadly utilized the world over, is spreading the products on ground in open sun until it dried. However, there are many issues with this method in cloudy and rainy days, bug invasion, abnormal state of soil and environmental contamination and interruptions from creatures and men. Likewise this there is no control on the drying procedure. Consequently, developing countries, accepting critical measure of solar radiation must understand the significance of controlled drying utilizing solar energy.

As of late solar energy have been utilized for drying and dehydration of different horticultural and sustenance items. A few solar drying strategies are produced for drying different nourishments in lesser drying time with better quality. In spite of the fact that a similar predominant quality item can be acquired by utilizing electricity but these processes are costly. There is additionally deficient supply of power in country zones. Solar energy based crop dryers shows up progressively to be appealing as business suggestions.

India gets colossal measure of solar energy in multiyear which is the measure of energy that could be used for thermal applications, particularly in crop drying. Drying is quicker in solar dryer, as the dryer chamber temperature is much more than outside. Drying speed is very fast so spoilage of food is very much less. The drying product is also protected against insects, irritation, residue, rain etc. product can be kept in the dryers for night time and in the rainy season as well. Product quality also retains with cleanliness. Three distinct types of either normal or constrained convection solar drying framework can be distinguished in light of plan course of action of framework parts and method of use of solar heat, in particular (i) direct type solar dryers, (ii) indirect type solar dryers, and (iii) hybrid solar dryers.

1.1 Direct solar drying

In direct solar dryer, most glazing materials are transparent in the solar short wavelength and opaque in the infrared long wavelength. Placing this type of material over the agricultural commodity will produce a greenhouse effect to trap solar energy in two ways: (i) the glazing acts as an opaque cover to thermal heat radiations emitted by agricultural commodity, thus trapping its heat within the cover (however, much of reflected radiation will be lost through the cover) and (ii) convective heat loss is reduced by the glazing cover which serves as an envelope. The principle is generally known as closed sun or direct solar drying.

1.2 Indirect solar drying

Drying unit is associated with the air heater in indirect solar dryers. The approaching solar radiations are used to heat the air, which is provided to the drying unit for reducing the moisture in agricultural products. The performance of the system is enhanced by incorporating the multi pass mode of air heating system. Heat losses in this case are less than the earlier principles and drying is maintained under control, hence produce a better quality product. It is generally referred as indirect solar drying.

1.3 Hybrid solar drying

Mixture of both type solar-energy based dryers discussed above are known as Hybrid solar dryers. Here the air to be transferred in drying chamber is preheated in air collectors before it directed towards the drying chamber where product kept is getting direct solar radiation which increases its thermal efficiency.

Chapter 2. Literature Survey

The brief review of literature on the importance of the solar energy based dryers used for drying of crops/vegetables of an indirect, direct and hybrid PV-T system and its relevance with its societal outcomes is discussed below.

2.1 Indirect solar drying

Maiti, et. al. in 2011 designed a small scale indirect type solar dryer for apple drying. Its collector efficiency without load was increased by 18% even in the month of January when it was associated with North-South reflector.[1]

El-Sebaii, et. al. in 2013 designed forced convection solar dryer in which drying chamber is connected with a double pass v-corrugated plate solar air heater. Heated air used for drying was directed towards the drying chamber. Heated air was fed into the drying chamber using dryer. Drying behavior of different products has been studied with 14 different mathematical models and Midilli and Kucuk model is fond best among other thin layer solar drying models.[2]

Musembi, et. al. in 2016 designed indirect solar dryer were air was circulated naturally. Fabrication of dryer was cheap made by using locally available materials and it was found that its overall efficiency was 17%.[3]

Lingayat, et. al. in 2016 proposed a FPC indirect solar dryer with V-Corrugated plates. Drying chamber and chimney of this dryer was insulated. Drying chamber was developed from aluminum sheet. The average thermal efficiency of the collector and drying was 31% and 22% respectively.[4]

Hazar, et. al. in 2017 proposed an indirect solar which consists of aluminium corrugated plate. To circulate air along the collector, aluminium plates are used as cylinders where air is preheated. Wet product to dry is in the drying chamber and exhaust air goes out by chimney. Its average thermal efficiency was 11%. [5]

El Khadraoui, et. al. in 2017 developed a force mode indirect type solar dryer using Phase Change Material (PCM). Drying agent is heated by using solar collector. Dryer consists of a drying chamber with solar energy accumulator. The solar energy accumulator along with PCM maintains the relative humidity 17 to 34% lower and temperature into the drying chamber by 4 to 16°C higher than the relative humidity and ambient temperature respectively.[6]

Castillo Téllez, et. al. in 2018 designed direct and indirect Solar dryers for drying Stevia leaves. Natural and forced convection mode was presented. In indirect solar drying product

condition was better, operating conditions can be controlled. In natural convection, drying time is less and when it is integrating with the shadow-mesh, quality of the leaves was also improved.[7]

2.2 Hybrid solar drying

Mixed mode dryer is also known as passive dryer because it has no moving parts. Dryer procures energy from the sunbeams that entering the collector. A hybrid PV-T greenhouse dryer has been designed by Barnwal, and Tiwari, in 2008, for grapes which has a DC fan for forced convection. Natural convection was found better than forced convection after testing for both the methods.[8]

Nayak, and Tiwari, in 2008 performed energy matrices analysis to predict performance of a PV-T greenhouse collector with forced convection mode. solar cell temperature is higher than tedlar back surface temperature by 3 to 4^{o}C and higher than greenhouse temperature by 15 to 16^{o}C.[9]

Nayak, and Tiwari, in 2009 studied effectiveness of PV-T and EAHE which is integrated with green house using mathematical modelling. Calculations are made around the year. In winter season greenhouse temperature is increased by 7 to 8^{o}C which is suitable for growing plant in this season.[10]

Agrawal, and Tiwari, in 2011 made an attempt on a hybrid micro channel PV-T based solar dryer for Energy matrices analysis. Evaluation made for different condition of weather. After getting results it is concluded that overall thermal energy of this system is increased by 70% and same for exergy is increased by 60% as compared to single channel PV-T module.[11]

Kamthania, et. al. in 2011a evaluated the performance of hybrid PV-T solar dryer with double pass facade. Using the laws of thermodynamics, energy balance equation was made and it is concluded that annual electrical energy and thermal energy increased in case of semi-transparent PV module.[12]

Kamthania, et. al. 2011b analyze the performance of semitransparent hybrid PV-T double pass air collector for quasi-steady state. Energy matrices analysis was made for five different cities for a year. After all analysis best place for installing the above mentioned setup was found.[13]

Agrawal, and Tiwari, in 2012 had done an exergoeconomic analysis by using glazed hybrid PV-T air collector for energy saving. It has more potential as compared to PV module. It was also very useful for space heating in cold areas and medicinal plants drying. It was also useful for the electricity generation.[14]

Agrawal, and Tiwari, in 2013 compared energy and exergy and carbon credits earned for different type of PV-T air collector in cold climate and it has been concluded in glazed and unglazed hybrid PV-T air collector energy gain is higher as compared to conventional one.[15]

Nayak, et. al. in 2014 concentrated out to assess the thermal and exergy execution over a year for a hybrid PV-T greenhouse dryer by considering different photo voltaic. After all the analysis it is suggested that c-Si compose PV module was most extreme because of the most noteworthy module productivity and most noteworthy expected life.[16]

Gudiño-Ayala, & Calderón-Topete, in 2014 made an experiment on solar hybrid dryer and simple drying under sun beam for pineapple drying. The hybrid dryer is direct and integrated type consists of copper helical hot water tube. it is observed that drying time is 17% longer in case of drying under solar radiation as compared to other one.[17]

Agrawal, and Tiwari, in 2015 analyze performance by analyzing carbon credit earned for a glaged hybrid PV-T air collector, annually in New Delhi. Huge abatement in annual cost was observed due to carbon credit earned.[18]

Rajoria, et. al. in 2015 studied an impact of EPT and carbon credits earned on life time cost to explore the of various PV-T thermal system. In life cycle cost if PV-T array cash flow is considered the annualized uniform cost has expanded by 7.0% to 16%. These qualities presumed that this approach is more effective than the traditional approach.[19]

Tiwari, et. al. in 2016 made an idea for analysis of PV-T mixed mode greenhouse dryer. In this setup to run DC fan three PV modules were utilized and introduced on the rooftop to stay away from direct expose to product and extra power is stored. At long last it was presumed that the issue of de-colouration had been limited and quality was also improved by utilizing this setup.[20]

Nayak, and Narwal, in 2017 proposed the monetary investigation of drying process utilizing hybrid PV-T solar dryer with indirect forced mode of convection. It comprise of an air radiator with smokestack in drying chamber, with 3 plate in it. Efficiency and payback time under different loading condition of dryer was measured.[21]

Dorouzia, et. al. in 2018 built up a solar dryer for tomato using liquid desiccant. To provide the required electricity and recover the desiccant, a PV-T thermal solar collector was used in the dryer. After the analysis it was presumed that by utilizing the desiccant, the drying time reduced

by 27% while applying the actuation RH of 18%. Temperature increases from 60 to 70^{o}C prompts 10% decrease in drying time. In this case the solar electricity ratio is also higher by 2.2 times.[22]

2.4 Soft computing techniques

Erenturk, and Erenturk, in 2007 used genetic algorithm to optimize mathematical models and to estimate the moisture level, artificial neural network was used and it is concluded that the artificial neural network give better estimated value than other techniques.[23]

Tripathy and Kumar in 2009 proposed a food temperature was predicted during drying in solar dryer with the help of neural network in which effect of temperature variation on food product had been investigated. Input parameters were considered for mixed mode solar dryer. Optimal neural network was developed for testing and ANN method is recommended out of other techniques.[24]

Varol, et. al. in 2010 used sodium carbonate deca-hydrate as PCM in solar collector and evaluate its performance. Also its efficiency is compared with system with no PCM. Support Vector Machines (SVM) is recommended out of others for efficient results.[25]

Tomy, et. al. in 2016 analyzed the Performance of a FPC with Silver/Water nano-fluid using ANN. The heat transfer performance of the proposed method had been evaluated by experiment. The solar radiation heat flux is approx..1000W/m^2 and 5000 to 25000 is the range of Reynolds Number. The experimental results are then validated by ANN and it was found that the value of Reynolds number was 100000 with less than ±2% error.[26]

Mohanty, et. al. in 2017 used several soft computing approaches to predict solar radiation data. Relative error is calculated to evaluate the performance of the models. Results predicted by ANFIS are better as compared to the other techniques i.e. Radial Basis Function (RBF) and Multilayer Perceptron (MLP). Also the predicted results are used to calculate the efficiency of the FPC.[27]

Azadbakht, et. al. in 2017 dries samples at three different input parameters. Due to the change in these parameters effect on Energy utilization, exergy loss and efficiency was evaluated. ANN is usd to estimate the above mentioned parameters to simulate the drying process. It is concluded that efficiency was improved and exergy loss is reduced, as the considered parameters was increased.[28]

Kaveh, et. al. in 2018 used two different techniques to develop the model to estimate the drying characteristics of different crop products. Experiments were made at varying air velocity and temperatures. After comparing the results it was found that ANFIS gave better estimation for moisture ratio and drying rate than the ANN.[29]

In the present work, drying process will be carried out by taking locally available medicinal plants such as Tulsi, Pudina/Mint & Curry leaves. The proposed hybrid semi-transparent indirect solar dryer will be then simulated by using soft computing technique. The efficiency & exergy analysis of the above said dryer will also be calculated.

Chapter 3. Objectives

1. To develop simulation model under no load condition for hybrid greenhouse dryer & solar dryer by using soft computing technique.
2. To carry out experimental studies of various locally available medicinal plants.
3. To carry out energy and exergy analysis.
4. To evaluate CO_2 mitigation and carbon credits earned.

Chapter 4. Scheme of Chapters

Chapter 1: Introduction

This chapter deals with the importance of drying, requirement of solar energy for drying, hybrid system and its relevance and importance. The classification of various mixed mode dryer in present scenario, historical background and analysis of various nutrients in dried medicinal/vegetable powder have been discussed. The objective of the present study, approach involved, description of the instruments used has also been briefly discussed.

Chapter 2: Literature of Review

In this chapter, detailed literature have been discussed on solar dryers. Commonly solar dryer is categories into four different categories. On the basis of literature survey, research gap have been identified.

Chapter 3: Experimental Setup

This chapter deals with the experimental setup of the hybrid semi-transparent indirect solar dryer. After drying of locally available agricultural product using hybrid semitransparent indirect solar dryer, experimental observations of various climatic parameters is to be carried out and drying time for drying of various items to be recorded.

Chapter 4: Analysis

In this Chapter, simulation model for solar dryer will be made. Characteristics equation curves for hybrid greenhouse dryer and solar dryer will be developed. An energy and exergy analysis for hybrid semi-transparent indirect solar dryer will be carried out.

Chapter 5: Result & Discussions

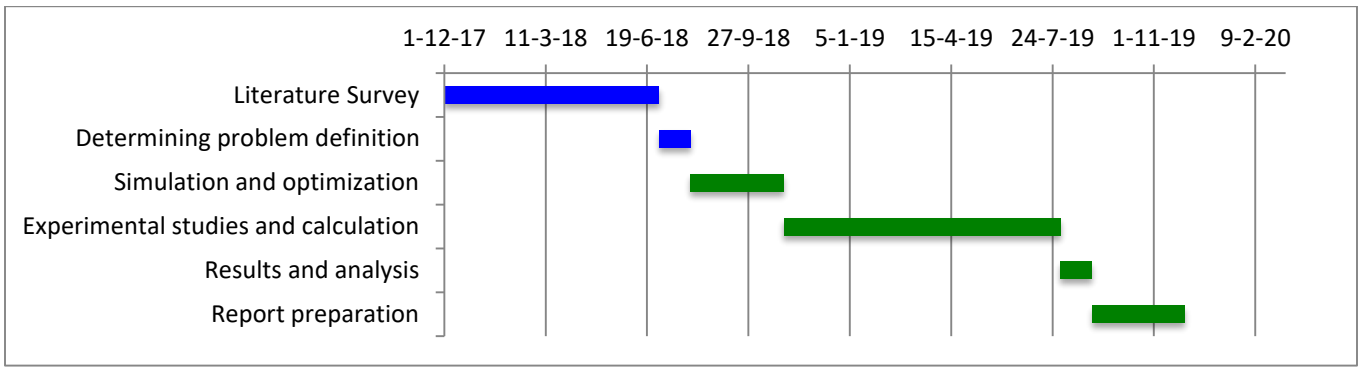
In this chapter, all the results optimized by soft computing technique will be discussed.

Chapter 6: Conclusion & Recommendation

This chapter deals with important conclusions of the study. Based upon experience gained during the course of investigation and experimentation, recommendations and suggestions for future work will also be reported.

Chapter 5. Work plan

Work plan for the proposed research is as follows:



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